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FATTERN PREDICTION OF ACADEMIC SUCCESS.

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A TECHNIQUE OF PATTERN ANALYSIS WHICH EMPHASIZES THE DEVELOPMENT OF MORE EFFECTIVE WAYS OF SCORING A GIVEN SET OF VARIABLES WAS FORMULATED. TO THE ORIGINAL VARIABLES WERE SUCCESSIVELY ADDED TWO, THREE, AND FOUR VARIABLE PATTERNS AND THE INCREASE IN PREDICTIVE EFFICIENCY ASSESSED. RANDOMLY SELECTED HIGH SCHOOL SENIORS WHO HAD PARTICIPATED IN THE WASHINGTON PRE-COLLEGE TESTING PROGRAM WERE ADMINISTERED A SECOND BATTERY THREE MONTHS LATER. CRITERION DATA WERE AVAILABLE ON MEN AND WOMEN WHO LATER ENTERED THE UNIVERSITY OF WASHINGTON. MEASUREMENTS INCLUDED TESTS OF ACADEMIC ACHIEVEMENT AND APTITUDE AND FIVE CRITERIA OF COLLEGIATE PERFORMANCE. THE PATTERNS INCREASED MULTIPLE CORRELATIONS IN THE WEIGHTING SAMPLE BUT CROSS VALIDATION SHRINKAGE WAS CONSIDERABLE EXCEPT WHERE THE ORIGINAL VARIABLES WERE MOST HEAVILY WEIGHTED. SUBPATTERN SCORING, IN COMMON WITH OTHER TECHNIQUES OF PATTERN ANALYSIS, MADE NO CONTRIBUTION TO PREDICTION OF ACADEMIC ACHIEVEMENT. THIS FAILURE IS SIGNIFICANT BECAUSE OF ATTENTION PAID TO THE SELECTION OF DIFFERENTIATED CRITERIA AND RELEVANT PREDICTORS. PATTERNS OF PERSONALITY NEEDS ASSOCIATED WITH ACADEMIC ACHIEVEMENT WERE ALSO STUDIED, BUT THE SAME LACK OF PREDICTIVE STABILITY WAS DEMONSTRATED. THERE WOULD SEEM TO BE SMALL ROOM FOR CONTINUING THE CONJECTURE THAT PATTERNS CAN GO ABOVE AND BEYOND PREDICTION FROM SIMPLE LINEAR FUNCTIONS OF ORIGINAL VARIABLES. (PR)

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Pattern Prediction of Academic Success

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A technique of pattern analysis was formulated utilizing only reliable subpatterns of scores and requiring repeated measures of original variables. To these original variables were successively added two-, three-, and four-variable patterns and the increase in predictive efficiency assessed. The technique was illustrated with a battery of academic achievement and aptitude measures and five criteria of collegiate performance. Patterns increased multiple correlations in the weighting sample but cross-validational shrinkage was considerable except where the original variables were most heavily weighted. Subpattern scoring, in common with other techniques of pattern analysis, made no contribution to prediction of academic achievement.

Using patterns in prediction is more than simply taking into account a number of different predictors. Ordinary multiple regression techniques already provide the means for linearly weighting several measures in the prediction of some attribute or performance. As typically employed, however, this technique falls short of utilizing pattern information because the weight assigned any particular variable remains fixed, independent of the level of other variables. For example, in predicting success in college mathematics on the basis of high school math grades and some test of quantitative aptitude, the contribution of a given grade average, say a "B," is the same for students of low, medium, and high quantitative aptitude. All this is not to say, however, that patterns cannot be adapted to the multiple regression solution.

There are two traditions regarding the use of pattern data in prediction studies. The first might be called the classification approach and is exemplified by the configural scale of Lubin & Osburn (1957) and by the significant

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pattern method of Forehand & McQuitty (1959). This approach emphasizes the unique assignment of each individual to one pattern. Pattern information over a given set of variables is assumed to be best represented by finding the single, most congruent pattern for every person. This assignment then substitutes for the original variables as the basis for prediction. McQuitty's more recent work on typing and hierarchical typing (1966a, 1966b) used this strategy. Attempts to use the classification approach for prediction have invariably led to severe shrinkage in cross-validation (Forehand & McQuitty, 1959; Lee, 1956).

The second tradition stems from Horst's suggestion (1954) that subpatterns of scores contain predictive variance. Studies belonging to this subpattern scoring approach include Alf (1956), Horst (1957), Lunneborg (1959), and Wainwright (1963). This approach assumes the individual can be assigned a multitude of scores each based on a subpattern. These subpattern scores can then be used with the original variables as a basis for prediction. This second approach emphasizes the development of more effective ways of scoring a given set of variables.

The present investigation represents an extension of this latter approach to the problem of estimating student success in each of a number of academic areas. Although the drop in validity when the classification approach is extended to a new sample may be a function of the approach per se, it might also be a function of utilizing too global a criterion (Forehand & McQuitty, 1959; Lee, 1956). Equally important, however, in the present study are the routines adopted for reducing the number of subpatterns from the total number dictated by all possible configurations.

It is not only computationally infeasible to consider all possible patterns in a given study but the weights derived on a particular sample inevitably undergo the shrinkage typical in cross-validation when any large number of variables enters into multiple regression. Therefore, all attempts at the subpattern approach have included techniques for reducing the number of subpatterns studied. Alf (1956) relied on a single predictor selection analysis while Horst (1957) and Lunneborg (1959) introduced tests of the potential effectiveness of groups of these subpatterns. In the present study, an initial screening of patterns was undertaken to eliminate those not occurring reliably from sample to sample or occurring with but very limited frequency. Reliable patterns were then studied systematically, by determining the increase in predictive efficiency of adding to the original variables first the two-variable patterns of scores, then three-variable patterns, and so on, with cross-validation at each stage.

Method

Subjects. A randomly selected group of 3,000 high school seniors who had participated in the Washington Pre-College (WPC) Testing Program in January 1964 were administered a second battery three months later. Criterion data were available on 179 men and 127 women who entered the University of Washington in 1964 and 1965.

Predictors and Criteria. The first battery consisted of the WPC tests of: English usage, spelling, reading comprehension, mechanical knowledge, spatial relations, applied mathematics, vocabulary, mathematics achievement, and a three-part test of quantitative aptitude. The second battery administered consisted of: Guilford-Zimmerman Aptitude Survey Part I, verbal comprehension and Part VII, mechanical knowledge; the

American Council on Education Psychological Exam, quantitative part only; Cooperative English Test, Form OM, Part I, English usage and Part II, spelling; and the College Entrance Examination Board achievement test in intermediate mathematics, Form CAC 1. The purpose of this dual testing, incidentally, was to replace the second battery of older, commercially available tests with a unique set designed for the Program by Educational Testing Service. In addition to these tests, predictors included sex, age, and six high school GPA's: English, mathematics, foreign language, social science, natural science, and electives.

The criteria were the average grades over 1964-66 at the University of Washington in four areas, English, mathematics, foreign language, and physical science, as well as the dichotomous criterion, satisfactory progress towards the bachelor's degree, defined as 36 or more credit hours per year and GPA no less than 2.00.

Procedure. The batteries together with the non-test predictors were separately factor analyzed (Lunneborg, in press). The first seven principal axis factors of each analysis were then matched according to the oblique maximum variance method (Horst, 1965). These analyses were based on the entire group of 3,000 students. Factor scores for the first five maximally congruent variables in the two sets were then determined for those 306 subjects for whom criterion data were available. These factor scores were computed in standard score form with a mean of 50 and standard deviation of 10 based on the group of 3,000.

These factor matching scores were used in the absence of test-retest data on either battery. Test-retest information was necessary for the definition of consistent patterns. It has previously been shown that

these two test batteries have very congruent factor structures (Lunneborg, in press) and, consequently, that administering both provides the necessary reliability data for factor scores. However, because these matched factors have been defined so as to be maximally congruent, rather than with any simple or psychological structure in mind, it is not possible to describe them simply in terms of certain battery tests, e.g., verbal aptitude, high school achievement, general intellectual ability, etc. Rather, each of the five factors was complexly related to all battery elements. For this reason the factors are throughout merely identified as Factors 1 through 5.

Each subject thus had five factor scores for each battery. These factor scores were trichotomized, labeling as high, scores above 56.6 (fourth quartile in a normal population), as medium, scores in the range 43.4 to 56.6, and as low, scores of 43.4 and below (first quartile). A pattern was thus defined as any combination of these trichotomized factor scores, for example, high Factor 1 - medium Factor 4, which occurred in any subject on both administrations. The maximum number of patterns possible for any individual based on five scores is 26,

$$(1) \qquad \sum_{i=2}^{5} \frac{5!}{i!\,(5-i)!} = 26 \;,$$

however, this maximum could only be reached if the two sets of five trichotomized scores were identical.

There are 1,008 possible patternings of five, four, three, and two trichotomized variables,

$$(2) \qquad \sum_{i=2}^{5} (3^{i}) \frac{5!}{i!(5-i)!} = 1{,}008 \;.$$

In any sample not all of these 1,008 patternings may occur or some of them may occur with such low frequency as to be of no practical interest. In the current study the only patterns investigated were those which occurred in more than 5% of 15 of the subjects. Subjects were randomly divided into two equal sized groups, one for regression weight determination and the other for validation of weights.

The contribution of patterns to the prediction of the five criteria of academic success was determined by a series of sequential predictor selections (Horst & Smith, 1950) each followed by cross-validation. Each predictor selection analysis added predictors only as long as the expected shrunken multiple correlation (R_c) did not drop. It was these correlations from cross-validation by which patterns were assessed as predictors. The following procedure was followed for each criterion: the first multiple regression analysis involved only the five factor scores from the first administration. Then five predictor selections were conducted adding to the factor scores the 50 two-variable patterns which had been found, ten at a time. As many variables as were selected in each of these five sequential analyses were submitted for a final one- and two-variable sequential analysis to produce the best set of predictor variables (with ten as the limit) for a given criterion. Following this stage, the 42 three-variable patterns which had been found were added to the best set of one- and two-variable predictors, fourteen at a time, making three sequential analyses. As many variables as were selected in each of these three analyses were submitted for a final three-variable sequential analysis to produce the best set of predictor variables (with ten again as the limit) for a given criterion. Lastly, to this best set

of one-, two-, and three-variable predictors were added the seven four-variable patterns for a final selection of the best ten predictors for each criterion.

Results and Discussion

As mentioned above, in the sample of 306 Ss there were 50 two-variable, 42 three-variable, and 7 four-variable patterns which occurred consistently and with a frequency of at least 15. Inter-correlations among these patterns, the five factor scores and five criteria for the weighting sample formed the basis for all subsequent predictor selections.

As seen from Table 1, in the predictor selections involving only factor scores no more than three factors were selected for any criterion. Equally noteworthy was the selection for all criteria of Factor 3, giving it the appearance of a general factor. These results were a function of the rotation of the battery factors to maximal congruence and doubtless a rotation to simple structure would not have produced the same selections.

With respect to the selections involving patterns, there was considerable variation among the criteria in the extent to which factors as opposed to patterns were selected. There was also variation not obvious in Table 1 in the order in which the two were selected. For both English and mathematics two of the first three variables selected were always factors. In contrast, only Factor 3 was involved in the selections for foreign languages and satisfactory progress although it was always first selected for the former and second selected for the latter. For physical science, factors were never included within the first four predictors selected. The predictor selection techniques tended to insure that earlier selected variables received the greater weight.

Table 1

Original Multiple and Cross-Validation Correlations for

Selections of Best Sets of Factor Scores and Patterns

for Five Academic Criteria

(Decimal points omitted)

	Criteria																			
	English				Mathematics				Foreign languages				Physical science				Satisfactory progress			
Selections	F only	F 2VP	F 2VP 3VP	F 2VP 3VP 4VP	F only	F 2VP	F 2VP 3VP	F 2VP 3VP 4VP	F only	F 2VP	F 2VP 3VP	F 2VP 3VP 4VP	F only	F 2VP	F 2VP 3VP	F 2VP 3VP 4VP	F only	F 2VP	F 2VP 3VP	F 2VP 3VP 4VP
Predictor types																				
Factor scores (F)	3	2	2	2	3	2	2	2	2	1	1	1	3	2	1	1	3	1	1	1
Two-variable patterns (2VP)		6	4	4		5	3	3		9	4	4		8	4	4		6	6	5
Three-variable patterns (3VP)			3	2			3	2			5	5			5	4			3	2
Four-variable patterns (4VP)				1				1				0				1				2
R_c	43	50	50	50	37	49	50	50	45	60	65	65	45	68	74	74	39	51	56	55
r_v	57	47	49	49	51	38	38	39	41	22	27	27	52	30	30	30	35	21	21	21

Note.--R_c is the multiple correlation obtained in weighting sample (N = 153) and reduced for expected shrinkage; r_v is the correlation obtained in the cross-validation sample (N = 153) between criterion and weighted sum of predictors. Ten was limit on all selections.

These differences among criteria in predictors selected and in orders of selection were reflected in the cross-validation results where the most general conclusion must be that patterns lack predictive stability from sample to sample. Where more than one factor was weighted and where factor weightings were relatively heavy, cross-validation correlations held up. But where patterns were more heavily weighted, the very high correlations in the weighting sample underwent marked shrinkage in cross-validation.

The failure of pattern information to aid prediction confirms the negative results of earlier attempts to use patterns and is all the more poignant a failure because of the attention paid to the selection of differentiated criteria and relevant predictors. There are even well-developed ideas throughout the educational literature as to the different configurations of abilities intuited behind different achievement criteria. In response to similar speculations in the counseling literature regarding patterns of personality needs associated with academic achievement, a study of reliable, frequent EPPS need patterns demonstrated the same lack of predictive stability (Lunneborg & Lunneborg, 1966). Given the content similarity in the present study between predictors and criteria, the use of only reliable patterns, and the refinement of criteria, there would seem to be small room for continuing the conjecture that patterns can go above and beyond prediction from simple linear functions of original variables.

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